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WASTE AND DISPOSAL SYSTEM

I. Introduction

The HRT summary report for the Advisory Committee on Reactor Safeguards refers to a limit on reactivity of ~ 1000 cnt/min/ml for condensate before release to the 300,000 gal. waste pond where it could be held for further decay. This same report requires a hold up of fission product gases sufficient to reduce the activity of the discharged gas "to a few curies per day."(1) R. E. Aven(2) has used a total value of 20 curies in a 24 hr period, which equals an average of 232 uc of activity per second as the maximum allowable release rate.

Should spills, leaks or accidental discharges of radioactive materials from any source occur, the material will be collected in the cell sumps which have been installed in lieu of floor drains. In the event of a leak developing in the system, or mechanical failure of a piece of equipment, the cell can be flooded to provide the shielding required to permit the removal of the roof plugs for access to the affected parts.

These conditions require the handling of liquids ranging from large volumes of very low activity contamination to small volumes of high activity.

The waste collecting and disposal system has been designed to provide controlled handling and disposal of both liquid and gaseous wastes under widely varying conditions so that limitations on released radioactivity can be met.

II. Summary

Waste and vent systems as used in this memorandum cover the systems shown on Waste and Vent System Flowsheet drawing D-18309 and described as:

A. Venting & Evacuation

Venting of the reactor and chemical processing cells is accomplished by a 1400 cfm fan which withdraws cell air and discharges through a MSA Ultra-Aire space filter to a stack 100' high. Vacuum pumps are used to evacuate the cell to 7-1/2 psia. An air inlet valve is provided on the water fill line header for bringing the cell to atmospheric pressure prior to flooding.

Vents are provided on the 12,000 gal. waste tank and the 1000 gal. waste condensate tank. These vents are terminated in the 16" cell ventilation line upstream from the stack fan and filter. The stack drain line, which has a 6" water leg, drains into the 12,000 gal. waste tank and will relieve pressures above a 6" head. The 1000 gal. waste condensate tank overflow drains to the 12,000 gal. waste tank through a line tied into the stack drain line.

B. Flooding

The reactor and chem.-tech. cells can be flooded with process water directly from the X-10 distribution system. A header and valving station permits the cells to be selectively flooded. The same lines are used to evacuate the water from the cells. A 1000 gpm pump pumps the water directly to the 300,000 gal. waste pond; however, the water lines are terminated in the cells 12" above the floor to prevent discharging the last 12 inches of water by this means.

C. Liquid Waste

1. Liquid wastes are collected in sumps in the reactor and chemical processing cells, and in the east valve pit. These sumps can be selectively discharged to the 300,000 gal. waste pond or the 12,000 gal. waste tank by steam jet pumps.

2. Liquid wastes in locations where only slight contamination is possible are drained directly to the waste pond.

3. Emergency evacuation lines extended from the cell sumps to the east valve pit are available for evacuating highly contaminated solutions directly into a carrier. These lines have welded caps and are strictly for emergency use.

4. The sample stations at the east and west ends of the reactor cell have gravity drains which discharge to the 12,000 gal. waste tank.

D. Evacuation of Holdup Tank

The holdup tank (Item 22) discharge line is routed through the east valve pit where a tee connection sealed with a welded cap is located for possible emergency use. The line terminates in the Chem.-Processing loading pit and is valved for normal use.

E. Steam Blowdown From Heat Exchangers

Blowdown lines from the heat exchangers are valved so as to permit the selective discharge into either the 12,000 gal. waste tank or the 300,000 gal. waste pond.

F. Disposal

Liquids collected in the 12,000 gal. storage tank can be transferred to an evaporator on a batch basis. The concentrated solutions can be discharged to a shielded carrier for transport to the chemical processing facilities and the condensate is collected in a 1000 gal. waste condensate tank, (Item 93). This tank can be selectively discharged into the 300,000 gal. waste pond or returned to the 12,000 gal. waste tank.

G. Gaseous Wastes

Fission product gases, stripped from the process system are passed through an activated charcoal bed for holdup and decay, and then through a filter to the stack. The gas is normally vented through seal pots, with sufficient mercury head to prevent reverse flow through the seal pot. A vacuum pump is also provided for evacuating the beds if it becomes necessary. Sampling connections for the "off-gas" are provided before entry to the charcoal beds and after leaving the beds.

H. Waste Storage Emergency Overflow

Should an emergency situation arise in which it is necessary to continue pumping into the 12,000 gal. waste tank after it is already full. the overflow will back up through the vent line into the east valve pit. The east valve pit in turn has a gravity drain to the 300,000 gal. waste pond with an invert elevation one foot below the point where the cells and other equipment might start flooding.

III. Discussion

The protection afforded by the overall reactor design and construction permits the personnel operating areas to be drained directly to the natural drainage ditches. The yard area, service buildings and roof areas are drained conventionally to surrounding natural drainage ditches. Floor drains in the control rooms, offices and locker rooms are drained by gravity or through sumps with conventionally operated sump pumps to the storm drainage system. The sump in the lowest level of the control area in addition to the floor drains, collects the ground water seepage; any leakage which might develop in the north shield wall; the overflow from the west sampling station cooling water; and the floor drain in the turbine generator base. The storage pit used to store equipment while waiting for it to cool off (radioactively) has an overflow which drains directly to an open ditch. The East sampling station cooling water is also drained to this pit.

Areas where contamination is never expected to exceed limits, in the range of 1000 cnts/sec/ml referred to in the introduction, permit the drainage of liquid waste directly to the 300,000 gal. waste pond.

The bulk of the water used to flood the cells is one such area. This water is drained to the storage pond through the lines used to fill the cells. A valve header is located in Cell A at floor elevation 805. Connected to this header is a 4" feed line from the X-10 process water system; a thousand gal. per min. pump for pumping water to the 300,000 gal. waste pond; and a 4" vent line for filling the cell with air to equalize cell and atmospheric pressures.

Water to fill the cell is supplied by the X-10 process water main system and a maximum of 1500 gal. per min. can be supplied. This supply is divided between the ARE and the HRT projects. The estimated supply available to HRT is 850 gpm.

Assuming 150 gpm is needed for cooling, then:

Water supply	850 gpm
Water used for cooling	150 gpm
Net available for filling cell	700 gpm

Volume of Reactor Cell

28,080 ft^3 x 7.48 gal.	=	210,000 gal.
Allowing 10% for equipment	=	20,000
Volume to fill	=	190,000 gal.

$$\frac{190,000}{700 \times 60} = 4.5 \text{ hours to fill}$$

Draining the cell with a 1000 gpm pump can be accomplished in ~ three hours.

The suction end of the lines is 12" above the reference floor elevation and ~ 18" above the sump. The only means of removing the remaining water is by use of the steam jet pumps. The discharge lines from the steam jet pumps pass through the waste tank valve pit where the line splits and can be directed either to the 12,000 gal. waste tank or the 300,000 gal. waste pond.

The chem.-tech. cells B & C are served through the same header in cell A and evacuated by the same 1000 gpm pump and a similar steam jet arrangement. These cells are each 12' x 24' x 20' deep and hold 42,400 gallons.

Other areas which are drained directly to the 300,000 gal. waste storage pond are cells D & C in the chem.-processing wing and the hot storage pool using steam jet pumps; the evaporator loading pit and the waste valve pit by gravity; and the overflow from the east valve pit.

Areas where contamination is expected to be slight but which may become contaminated through mishaps or faulty operation are routed through the waste tank valve pit where they may selectively be directed to the 12,000 gal. storage tank or the 300,000 gal. storage pond by a manifold and valving arrangement. The following locations are piped to the manifolds in the waste tank valve pit:

1. Steam jet discharge lines from both the fuel and blanket ends of the reactor cells.

2. Steam jet discharge lines from both chem-process cells B & C.

3. Steam jet discharge from the chem-process loading pit.

4. Steam jet discharge from the east valve pit.

5. Steam jet discharge from the waste condensate tank.

6. Steam blowdown lines from the main heat exchangers.

These lines are all S.S. except for the steam blowdown line, which is carbon steel. A stainless steel check valve is placed in the normally open discharge to the 300,000 gal. tank which in turn is connected to the stainless steel discharge manifold with stainless steel pipe. Likewise, the normally closed valve to the 12,000 gal. tank is stainless steel and forms the transition to stainless steel in that branch. These valves and transitions to stainless steel pipe are in the waste tank valve pit and protect the carbon steel blowdown line from the corrosive acids which flow through the manifold header.

Areas listed below are subject to severe contamination under normal operating conditions and are piped direct to the 12,000 gallon waste tank.

1. Sample drain lines. The sampling procedure calls for flowing process fluid through the sampling isolation chamber to purge it. Should any of the purge fluid drip from the isolation chamber, or a break in a line permit process fluid to be discharged into the sampler housing, it would drain directly to the 12,000 gal. tank.

   The sampler drain line has been embedded in the South wall of the East valve pit and a vent connection tied into the 16" vent line in the East valve pit. This serves as a vent line for the 12,000 gal. tank and also serves as the overflow for the 12,000 gal. tank described previously. When acting as an overflow line a U-trap in the bottom of the 16" vent pipe permits the flow of liquid into the East valve pit.

2. A drain at the bottom of the stack is trapped with a 6" water leg to prevent it acting as a vent and is piped directly to the 12,000 gal. waste tank. This line will act as an emergency relief to prevent pressure building up in the waste tank.

3. The sump jet pump discharge from the waste evaporator building is piped directly to the waste tank.

4. The overflow from the waste evaporator is returned to the 12,000 gal. waste tank. This line is trapped(3) with a 12" water leg to prevent steam developed in the evaporator escaping to the waste tank.

5. The drain in the housing for the waste evaporator sampler is connected by a welded tee into the waste evaporator overflow line, underground, near the Southwest corner of the waste evaporator building and drains into the waste tank.

A break in the process fluid or blanket lines could fill the sumps with fuel solution, and it may become desirable to recover such material without resorting to the use of the waste evaporator. To provide for such a contingency 1/2" stainless steel "scavenger" lines have been installed from the sumps in the reactor cell and chem.-processing cells B & C to the east valve pit where they are terminated and sealed with welded caps. It will be necessary to cut the caps off of these lines and provide emergency carriers and suction equipment to utilize these lines.

Separate shielding was considered for the heat exchangers and storage tanks. Partition walls around these units, 13 ft. high were designed and the structural supports for these walls were installed. Fill lines (2" pipe) were added to the filling and evacuation headers in cell A and the piping installed.

The 1/4" plate wall installation has been deferred until it has been demonstrated more clearly that separate shielding for the outer dump tanks is necessary or desirable.

The foregoing discussion has detailed the methods by which the liquid wastes containing contamination in the form of radioactivity are collected in either the 300,000 gal. waste pond or the 12,000 gal. waste tank.

The radioactive material in the waste pond will be held until it has decayed sufficiently to permit its release to Milton Creek.

The material in the 12,000 gal. waste tank will be treated before disposal. A dip leg with a steam jet pump will transfer this effluent to the waste evaporator(3)(4) where it will be concentrated by boiling off the H_2O. The evaporator has 3 reboiler legs of 4" pipe. The volume of concentrated effluent in these three legs is greater than the sample carrier, therefore bayonet heaters were added so the concentrated effluent could be reduced to less than 4 gal. This will assure that the 5 gal. carrier will not spill over into the evaporator loading pit. The loading pit is located at the SE corner of the evaporator house. Drains, with gravity flow from the bottom point of the evaporator, are piped directly to this pit. A connection is provided in the drain line, after it enters the pit, where either steam, air, or water could be connected to flush the drain line back into the evaporator should it plug or otherwise become desirable. The vapor from the evaporator is condensed and collected in the 1000 gal. waste condensate tank from which it can be recirculated through the 12,000 gal. tank or transferred to the waste pond. The concentrated effluent is shipped in a shielded carrier to a Thorax plant for processing.

The reactor and chemical processing equipment is designed to operate in a sealed cell operating at 7-1/2 psia. Two vacuum pumps with 2" suction lines evacuate the cells to maintain the required negative pressure.

When the cell is opened a 16" duct and a 1400 cfm stack fan provide an inward flow of air through the opening. (12" ducts to cell B & C).

The air evacuated by either the stack fan or the vacuum pumps passes through a chemical warfare filter capable of removing all particles 0.3 microns or larger. To avoid unnecessary plugging of this filter the following arrangement is used.

The filter is mounted between the 16" cell vent line closure valve in the east valve pit and the stack fan. A weight loaded damper mounted on the low section of roof over the chemical process office is connected to the duct between the filter and the fan to provide the necessary flow of air for the fan when the cell valve is closed. Vent lines from the waste and waste condensate tanks are connected to the 16" duct between the valve and the filter, and are continuously vented through the filter. The vacuum pump discharge passes through a roughing filter which will remove 98% of particles 1 micron or larger in size, then to the 16" duct upstream from the filter so that it is continuously filtered. The off gas lines from the adsorber bed are also connected to the 16" vent line upstream from the filters and are continuously filtered.

The fission product gases which are stripped from the process lines and passed through the cold traps, are piped in stainless steel tubing to the adsorber bed. The natural convection recombiner on the fuel storage tank reflux condenser normally operates without venting. A vent line 134 is provided to vent the fission product gases if it becomes necessary or desirable. This vent bypasses the cold traps and is connected directly to line 117. The lines are shielded by lead in the east valve pit and run underground with a minimum of 10 ft. of earth for shielding after leaving the building. The adsorber beds are designed (see ref. (5) through (12) incl.) to reduce the activity to 6.45 curies/day of 10.27y Kr85[10].

This activity is continuously discharged to a ventilation stream of 1400 cfm. and out the 100 ft. high stack.

$$\frac{6.45 \times 10^{6}}{1400 \times 60 \times 24 \times 2.832 \times 10^{4}} = 1.13 \times 10^{-4} \ \mu c/cc$$

The permissible values for beta-gamma, airborne contamination is

without a mask[13] 1×10^{-8} $\mu c/cc$

Reference to the TVA, Bethel Valley Quadrangle, Fig. 1, Dwg. 8584[14] shows contour elevations of 1000 ft. not more than 2000 ft. north and north east of the HRT building. A rule of thumb method[15] for estimating the required effective stack height to eliminate the non-meteorological downsweep of stack effluent from local obstructions is "2-1/2 times the height of any structure located within 20 lengths of the stack".

The HRT stack rises 100 ft. above Elev. 830 and is more than 70 ft. below the hills to the N and NE, within 20 stack lengths, so it must be presumed the non-meteorological downsweep will be a greater factor in bringing the stack effluent to the ground level adjacent to the HRT building than normal meteorological phenomena.

Winds[14] from the north and northeast, based on average annual frequency, are prevalent;

38.0% of the time under inversion conditions,

29.7% of the time under lapse conditions, and

34.0% of the total time.

Suttons formulae[15] rarely shows a lateral dispersion of a point source of more than 20°. Assuming a dispersion of the downsweep as a cone with a 20° apex angle,

then, $(100 \times \tan 10^{\circ})^2 \times \pi = 980 \text{ ft}^2$ area at base.

This is a dispersion factor of 980 and the effluent concentration at the ground would be

$$\frac{1.13 \times 10^{-4}}{980} = 1.16 \times 10^{-7} \quad \text{uc/cc}$$

$$\frac{1.16 \times 10^{-7}}{1 \times 10^{-8}} = 11.6$$ times the permissible beta-airborne contamination.

From the above assumptions the dispersion rate will vary as the square of the distance traveled and would be below the permissible value for beta and gamma airborne contamination within a few hundred feet.

The calculations of activity at the ground level above are based on qualitative assumptions and only indicate that operating personnel may be subjected to excessive airborne concentrations of radioactivity at 10 MW operation.

In addition to the stack monitoring, regular sampling and analysis of the air in the vicinity of the building should be established as soon as the reactor is placed in operation, to check air contamination and determine the need if any for additional treatment of the stack effluent.

The adsorber beds are vented through Hg. seal pots. The pots are 6" in diameter and the 1/2" adsorber bed discharge lines are connected 1" below the surface and provide 1" of Hg. head loss. The lines are looped 30"+ above the seal pot and provide a positive seal against reverse flow of air due to vacuum suction. The seals prevent atmospheric H_2O and O_2 from entering the beds.

There are three separate adsorber beds which can be isolated from each other and each can be vented through the mercury pots or the vacuum pump. This flexibility is provided so a bed can be used to saturation, then isolated and permitted to decay, and finally regenerated by the vacuum pump without interfering with the operation of the other two beds which could be either isolated or vented normally through the Hg. seal pots. This is accomplished by an inlet header and valving station located adjacent to the adsorber bed and by three-way valves on the discharge lines at the stack.

REFERENCES

(1) ORNL-1834,"HRT Summary Report for the Advisory Committee on Reactor Safeguards",

(2) ORNL CF-56-6-142, "Gaseous Radioactivity From HRT Fuel Storage Tank", R. E. Aven.

(3) CF-55-11-143, "Study of HRT-CP Waste Evaporator, Entrainment Separator, Condenser and Related Piping", and a private communication from W. L. Carter correcting the pressure for entrainment separator from 2 psi to 2" of H_2O. Correcting the error in decimal placement the

$$\begin{aligned} \Delta P &= 4\text{" pipe} &&= .0252 \text{ psi} \\ &= \text{Entrainment sep. to cond.} &&= .0315 \text{ psi} \\ &= \text{Entrainment sep. } 2/12 \times .433 &&= \underline{.0721 \text{ psi}} \\ & && .1288 \text{ psi} \end{aligned}$$

$.1288 \times 2.309 \times 12 = 3.56$ in. H_2O.

A 12" leg was placed in the evaporator return line providing a factor of safety of 3^+.

(4) CF 54-7-122, HRT Entrainment Separator (For Dump Tanks), C. L. Segaser.

(5) CF-54-5-2, "HRT Evaporator Design Study", C. L. Segaser.

(6) CF-54-7-26, "Use of HRE Charcoal Adsorber in HRT", I. Spiewak.

(7) CF-54-7-122, "HRT Entrainment Design Study", C. L. Segaser.

(8) CF-54-12-143, "Operation of HRT Charcoal Beds at 10 MW", I. Spiewak.

(9) CF-55-8-145, "Shielding for HRT Charcoal Pit and Gas Lines", T. W. Leland.

(10) CF-55-9-12, "Design of Charcoal Adsorbers for HRT", T. W. Leland.

(11) Memo, M. C. Lawrence and M. I. Lundin to W. R. Gall on HRT Charcoal Adsorber Bed, Dated 8-9-55.

(12) CF-56-1-106, "Shielding of HRT Charcoal Pit and Off-Gas Line", J. O. Kolb.

(13) ORNL Health Physics leaflet X-630. The value given is ten times the Handbook 52 value for areas beyond the controlled zone. It is an action point established in order to meet the average limits given in HB52.

(14) ORNL-731, Series A - A report on the safety aspects of the Homogeneous Reactor experiment.

(15) Meteorology and Atomic Energy, published July, 1955, by U.S.G. Printing Office, by U. S. Weather Bureau for Atomic Energy Commission.